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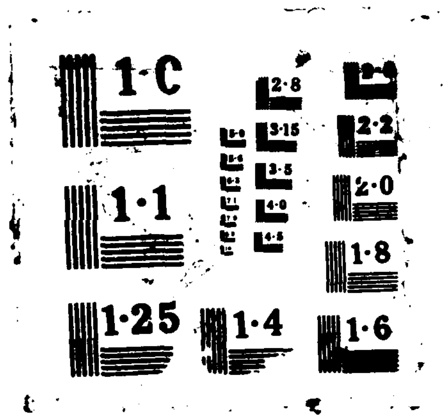
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19. ABSTRACT (Continue on reverse if necessary and identify by block number)

This project yielded the following significant new discoveries and findings about solar magnetic fields:

(1) The majority of magnetic flux on the sun is observed to disappear when magnetic fields of one polarity migrate into or develop in juxtaposition with fields of opposite polarity. This type of disappearance of magnetic flux is given the observational name "cancellation".

(2) The cancellation of magnetic fields can be interpreted as: (a) submergence (b) reconnection or (c) dissipation (annihilation) of magnetic fields. Reconnection is the favored interpretation to date, although further theoretical work needs to be done to definitively identify the physical mechanism represented by cancellation.

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(3) Large-scale filaments are observed to form in the chromosphere immediately above the boundaries between areas of network magnetic fields of opposite polarity where network cancellation occurs. The mechanism of formation is not yet understood.

(4) Small-scale filaments develop in association with small-scale cancelling magnetic fields at the rate of hundreds per day. Many of the small-scale filaments abruptly end their lifetimes of a few hours by outward expansion and eruption; such eruptions follow the same patterns as observed for large-scale filaments.

(5) ~~It was~~ found that magnetic fields associated with large-scale solar convection cells, known as "intranetwork" magnetic fields, can be detected everywhere on the visible disk of the sun by using the videomagnetograph to integrate successive, 1/15 sec. magnetic field images for intervals of 1 to 10 minutes.

(6) The intranetwork fields appear to be a few seconds of arc in diameter, and have field strengths of the order of a few Gauss to tens of Gauss.

(7) The intranetwork fields appear to originate at the centers of supergranules and flow to the boundaries of the cells in approximately radial patterns.

(8) As the intranetwork magnetic fields approach the cell boundaries, they often become enhanced before they either merge or cancel with the network fields at the cell boundaries or other intranetwork fields from adjacent cells.

(9) Solar flares in decaying active regions were found to invariably occur at the sites of cancelling magnetic fields. In an earlier study, a high percentage of flares (66%) in one complex active region were found to occur at the boundaries of emerging flux. We deduce from these studies and studies of other authors that the associations of flares with emerging and cancelling fields are not independent. We conclude that (a) emerging flux is related to flares only when cancellation also occurs; (b) cancellation can be driven by the emergence of magnetic flux but is not dependent upon emerging flux and (c) cancellation is a necessary condition for solar flare to occur. We anticipate that these significant new findings could be used to make a substantial improvement in the short-term forecasting of solar flares. The development of a practical forecasting scheme based on these findings, however, depends upon further statistical and quantitative analyses of the time-scale and magnitude of cancellation relative flare occurrence.

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THE APPEARANCE AND DISAPPEARANCE OF MAGNETIC FLUX ON THE QUIET SUN

FINAL TECHNICAL REPORT
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A. Research Objectives

Our research objectives during the first two years of this project were to study the earliest appearance of major regions of new magnetic flux at the photosphere. At that time we thought that the majority of magnetic flux on the sun originated in small bipolar fields known as ephemeral regions or large bipolar regions known as active regions. We sought to learn new information on the possible origin of the active regions by taking new and improved observations using the videomagnetograph at the Big Bear Solar Observatory.

Due to our success in increasing the magnetic signal in the videomagnetograms, in FY1983 we began to make new fundamental discoveries about the disappearance of magnetic flux. Therefore, we extended our research goals to include the disappearance as well as the appearance of magnetic flux.

Further improvement in the sensitivity of the magnetograms was achieved by the use of a new CCD video camera. This type of camera greatly aided our detection of the weakest known magnetic fields on the sun, now known as the "intranetwork" magnetic fields. We again extended the project to include our studies of the appearance and disappearance of the intranetwork magnetic fields. We thus opened new vistas of research and at the same time gained new possibilities for further exploring our original topic, the earliest phases of active regions. We could then look for possible inter-relationships between the intranetwork fields, and the much stronger magnetic fields of the ephemeral regions and active regions. Below we summarize our observational and instrumental progress and present the abstracts of the research papers in which we describe our many new findings on the appearance and disappearance of magnetic flux on the sun.

B. Summary of Improvements in the Acquisition of Videomagnetograms

The new findings described in the research papers (summarized in Section C) were achieved because of our efforts in improving the videomagnetograph and our techniques of data acquisition. We summarize these instrumental and data handling improvements in this section.

(a) Increased Integration Time

Our first improvements in the magnetograms were achieved in FY1982 by increasing the integration time of the magnetograms. A key feature of the videomagnetograph is that it is an integrating system; a videomagnetogram is a composite of many successive images each taken a the video scan rate of 1/30 second. We define an "integration" as the sum of two successive images in which the first image contains a component of polarized light representing positive polarity magnetic fields and the next image contains an orthogonal component of polarized light representing negative polarity magnetic fields. Prior to summing these two images, the gray-scale of one image is reversed. Then the result of this summation is a basic magnetogram in which positive fields are displayed as more white than a medium gray background and negative fields are displayed as blacker than the background. However, a single such magnetogram or "integration" contains very little magnetic signal. Consequently it is necessary to integrate many such successive image pairs to achieve a magnetogram with obvious magnetic fields. Our usage of the word "magnetogram" is the final image after a given number of pairs of images have been digitally added or "integrated".

Previous to this research program, an arbitrary limit of 500 integrations had been imposed in the videomagnetogram program because magnetograms of active regions were usually recorded at no more 128 integrations. It was thought that there would be no reason to exceed this 500 integrations because the strong fields became saturated at about 128 integrations and it was supposed that all significant magnetic fields were being recorded as well as possible.

When we began to systematically look for very small bipolar magnetic regions, known as ephemeral regions, it became obvious that the number of such regions detected was proportional to the number of integrations in the magnetograms. Therefore, the arbitrary limit of 500 integrations was removed and we began to experiment in taking time-lapse movies of magnetograms composed of many more integrations. It was found that many more ephemeral regions could be detected at about 1000 integrations. Furthermore, we began to detect very small, mixed-polarity, weak granular-like fields. These background fields had only previously been detected with the magnetographs at Kitt Peak and at the Lockheed Solar Observatories under conditions of very good seeing and had been referred to as "inner network magnetic fields". We discovered that we could record these weak background fields even in poor seeing if we integrated for sufficiently long times. Thus a new area of research was open to us.

It was also apparent that the long-integration magnetograms would be the key to the detection of the earliest phases of active regions. We had found in data of only 128 integrations that signs of new magnetic flux regions were recognizable in Ha filtergrams for an hour or more before the new flux region could be detected in the magnetograms. Clearly, then the long-integration magnetograms would be required to detect the earliest emergence of magnetic flux regions. Indeed, the next generation of long-integration magnetograms at about 512 integrations began to reveal new information. We now can observe the successive appearance and flow of discrete, small-scale, weak magnetic bipolar units at the centers of growing active regions.

One of the disadvantages of the long-integration magnetograms is that the strongest fields would reach saturation before the weak fields were sufficiently recorded. To adequately record both strong and weak fields, we began to continuously take series of magnetograms at differing numbers of integrations. Typical series of magnetograms on the quiet sun would be 512, 1024 and 2048 integrations. On active regions, a good combination was 256, 512 and 1024 integrations.

(b) Storage and Transfer of Digital Magnetograms

Until FY1984, the videomagnetograms were only recorded on photographic film. During this year a large effort was made to take the initial steps in calibrating the magnetograms and to record some of the magnetograms on storage disk of the computer for later transfer to magnetic tape. The digital recording of the magnetograms on magnetic tape enabled their analyses on a Grinnell image processing system (shared with the stellar astronomy department at Caltech). Our techniques of data analyses were thereby expanded. Programs were written to produce contour maps of the magnetic fields, to combine images acquired with differing numbers of integrations, and to calculate the magnetic flux of selected features or within selected areas of the images.

By FY1985, the digital magnetograms were proving to be so useful, that we began to systematically record all of the images directly onto magnetic tape as well as on photographic film. The films still provided the most efficient means of surveying the data and the easiest format for making prints of the magnetograms for publications. The magnetic tapes provided a more efficient means of calculating the magnetic flux via special programs.

During this same year a new programs was written to automatically photograph the digital images from tape in addition to the usual photographs taken during the observing days. The new program allowed us to make several separate time-lapse films for each observing day for each set of magnetograms with differing numbers of integrations. This was desireable in order to separately study the strong intermediate, and weak magnetic fields.

(c) New Supplementary Instrumentation

Another large gain in magnetic sensitity of the videomagnetograms was achieved late in FY1985 with the use of a new CCD video camera. The sensitivity was approximately doubled. The noise level also increased. We then recognized that the background noise contained several components, some of solar origin and some of instrumental origin. Both the solar granulation and the 5 minute oscillation are seen in the new magnetograms. For the present purposes, these solar features are considered as noise to be eliminated or minimized so that the weakest fields can be better detected.

In FY1986, a further improvement was achieved by the addition of additional memory to image digitizing system. This allowed us the option of digitizing to 12 bits instead of 10 bits at the expense of increasing the integration time by a factor of 4. Because our display systems are currently limited to 8 bits, the new option really meant that we had only a new choice of displaying the upper 8 bits. The advantage of the this choice has been the reduction of noise in the magnetograms because the noise level is greatest is the lower bits which are then not read.

During FY1986, a series of experiments were performed using a 1/8 A filter element borrowed from Sacramento Peak Observatory. Our initial goal was to determine if the sensitivity of the magnetograph could be increased by using a combination of filter elements to achieve a more narrow passband. The results of this test were negative on the 6103 CaI line. However, in order to conduct this experiment it was necessary to observe in only one wing of the line instead of both wings of the line. In tuning the filter combination through the line in very small steps, we found that one of the sources of noise in the magnetograms was coming preferentially from the passband in the red wing. Magnetograms in the blue wing were much cleaner due to the lower contrast of the solar granulation in the blue wing. Since that time we have taken the majority of videomagnetograms in only the blue wing to minimize the obscuring effect of the granulation on the weakest magnetic fields.

These changes in instrumentation and data handling, gradually introduced during the course of this research program, have made the videomagnetograph at Big Bear Observatory, the most sensitive solar magnetograph in the world. Many new discoveries about solar activity have resulted as summarized in the next section in the abstracts of research papers resulting from this program. The increased potential of the improved observations is continuing to be exploited.

C. Abstracts of Completed Research Papers

C.1

EMERGING MAGNETIC FLUX, FLARES AND FILAMENTS

S. F. Martin, L. Dezso, A. Antalova, A. Kucera, and K.L. Harvey

ABSTRACT

17 emerging magnetic flux regions with arch filaments related to new sunspots were identified in Hale Active Region No. 16918 during the 7-day interval from 16-22 June. Most of the new flux regions were clustered around the filament channel between the old opposite polarity fields as were most of the flares. The two largest regions of new magnetic flux and a few of the smaller flux regions developed very near the end points of filaments. This suggests that the emergence of flux in existing active regions might be non-random in position along a filament channel as well as in distance from a filament channel.

We have analyzed the positions of 88 flares to date during about half of each day. We find that slightly more than half (54%) of the flares, irrespective of their size, are centered within the new flux regions. About 1/5 (20%) were centered on the border between the new flux and the adjacent older magnetic field. Less than 1/3 occurred outside of the newly emerging flux regions but in many cases were very close to the newly emerging flux. We conclude that at least 2/3 of the flares are intimately related to the emerging flux regions while the remaining 1/3 might be either indirectly related or unrelated to the emerging flux.

DYNAMIC SIGNATURES OF QUIET SUN MAGNETIC FIELDS

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Solar Astronomy
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ABSTRACT

The motions of network fragments, ephemeral regions, and intra-network structures result in the frequent interaction of their magnetic fields. The merging of similar polarity magnetic fields from any of these sources occurs without obvious net change in the magnetic flux. However, when opposite polarity magnetic fields from any source collide, mutual loss of magnetic flux is observed to take place gradually in the colliding fields until the smaller magnetic field fragment completely disappears. Colliding magnetic fields of opposite polarity were always observed to have spatially separate origins; evidence of the submergence of an ephemeral region or any original bipole has not been seen.

The collision and disappearance of opposite polarity fields is observed most frequently at the borders of network cells. Due to observational limitations, the frequency, magnitude, and spatial distribution of magnetic flux loss have not yet been quantitatively determined at the borders or within the interiors of the cells. However, in agreement with published hypotheses of other authors, the disappearance of magnetic flux is speculated to be a consequence of either gradual or rapid magnetic reconnection which could be the means of converting magnetic energy into the kinetic, thermal, and nonthermal sources of energy for microflares, spicules, the solar wind, and the heating of the corona.

C.3

RELATIONSHIPS OF A GROWING MAGNETIC FLUX REGION TO FLARES

S.F. Martin[1], R. Bentley[2], A. Schadee[3], A. Antalova[4], A. Kucera[4], L. Dezso[5], Gezstelyi[5], K.L. Harvey[6], H.P. Jones[7], S.H.B. Livi[8] and J. Wang[9]

ABSTRACT

We have found that the flares in this complex have differing relationships to the growth of a new major flux region. The flares having the closest relationship to the new flux region are those that straddle the boundary between the new and pre-existing magnetic flux regions. The flares at 1859 on 20 June and 1910 on 21 June are of this type. Another group of flares originate at sites west of the emerging flux region where the relatively rapid motion of the leading polarity field pushes the pre-existing field of similar polarity towards an opposite polarity field. The 22 June flare is among this group of flares. The major flare on 21 June does not fit either of the above categories. There is little motion of the trailing sunspots toward the old polarity inversion line around which the flare begins. However, the magnetic field configuration suggests that magnetic reconnection could readily occur between the positive field associated with the trailing sunspots of the emerging flux region and the adjacent negative polarity pre-existing field. This offers a third possible relations hp to the new flux region. If the trailing, positive polarity fields of the new flux region slowly or intermittently reconnect with the negative fields of the old region, this reconnection would effectively "steal" old flux previously connected to its conjugate field over the adjacent old polarity inversion line. As the previous magnetic configuration changes, the filament along the old polarity inversion line reacts and begins to ascent into the corona. Finally the magnetic configuration in the corona changes from metastable to unstable and the flare occurs. Although we lack data to show direct evidence of such changes in the coronal magnetic field, we suggest that many flares associated with erupting filaments or "disparition brusques" occur as in this last scenario. As evidence of this third relationship, we cite the unusually high incidence of disparition brusques in the vicinity of new and growing active regions found by Bruzek (1952) and confirmed by Hermans and Martin (1984).

Although the emerging flux region described here had affected the flare productivity of the complex in these several ways described, we do not claim that all emerging flux regions are effective in generating the conditions necessary for flares. Especially when the rate of growth of a new emerging flux region is slow or the orientation is such that similar polarities of new and old flux can merge, we would not expect flares to occur. Additionally, we think that it is feasible for flare conditions to be generated in the absence of emerging flux.

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Hermans, L.M. and Martin, S.F., presentation at Workshop on Solar Terrestrial Predictions, Observatory of Paris at Meudon, 18-22 June 1984.

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C.4

THE DISAPPEARANCE OF MAGNETIC FLUX ON THE QUIET SUN

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ABSTRACT

Observations of the mutual loss of magnetic flux in closely spaced, opposite polarity magnetic fields on the quiet sun are illustrated in videomagnetograms from the Big Bear Solar Observatory. This observed type of magnetic field disappearance is herein defined as "cancellation" to differentiate this type of observed flux loss from the apparent loss of flux of one polarity previously reported in the literature. Cancellation is preceded by motion of either or both features of opposite polarity and does not occur until the features are in apparent contact. The number of observable cancellation sites depends strongly on the spatial resolution, temporal resolution, sensitivity, and noise level of the magnetograms. In the magnetograms analyzed for this paper, the number of distinct and spatially separate examples of cancellation varies from 1 to 8 per supergranule per day. For the examples studied, the duration of cancellation per feature typically is several hours and is of the order of 10 Mx/h. However, both the duration and rate depend upon the amount of flux involved in the cancellation and possibly several other factors such as the rate of prior motion of the colliding fields and whether the source of the cancelling fragments is from various combinations of network, ephemeral region, or intranetwork magnetic fields. Several possible interpretations of cancellation are discussed. Irrespective of the mechanism or mechanisms of disappearance, cancellation is seen to be the most common observed mode of disappearance of magnetic flux on the sun. Cancellation is also a principal factor in the redistribution of magnetic flux on the sun.

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C.5

THE CANCELLATION OF MAGNETIC FIELDS I - ON THE QUIET SUN

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ABSTRACT

We studied the disappearance of magnetic flux in an area of the quiet sun from digital and photographic magnetograms recorded at 2.5 min_. intervals for many hours on 9 July 1984 at Big Bear Solar Observatory. We limited the quantitative part of the analyses to features which had a total of 10E17 Mx or greater and at least one 20 Gauss contour, and which changed by more than 10% of the maximum measured flux during the 5.5 hours of most consistent image quality during the observing day. 16 examples of flux disappearance and 3 ephemeral regions met these criteria. The disappearance of flux in these examples occurred only in closely-spaced features of opposite polarity. The mutual disappearance of magnetic flux in closely-spaced features of opposite polarity is herein defined as "cancellation". The 16 examples of cancellation were observed in combinations of network features, intranetwork features, and ephemeral regions. In two of the three ephemeral regions, an imbalance of magnetic flux between the two poles within each of the ephemeral regions was created, at least in part, by the cancellation of one pole with an adjacent feature of opposite polarity. Many smaller cancellations are clearly recognized below the threshold that we established for our initial measurements. We conclude that cancellation is the dominant way in which magnetic flux is observed to disappear on the quiet sun.

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C.6

THE CANCELLATION OF MAGNETIC FLUX II - IN A DECAYING ACTIVE REGION

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ABSTRACT

An active region was studied in detail during its period of decay from 3 through 8 August 1984 using Ha filtergrams and videomagnetograms acquired at Big Bear Solar Observatory. The decay was initiated by a process of fragmentation in which very small knots of magnetic flux separated from larger concentrations of flux. The fragmentation was observed at discrete locations around the periphery of both the dominant areas of negative and positive field, but possibly occurred more frequently in the main polarity inversion zone. The fragmentation and migration of knots of magnetic flux were common predecessors to the disappearance of flux.

The disappearance of magnetic flux was always observed when the small fragments of flux encountered other small fragments or concentrations of flux of opposite polarity. This type of disappearance of magnetic flux, called "cancellation", is shared by both polarities of magnetic field. It was deduced that the disappearance of flux occurred either at or within 5 arc seconds of the apparent dividing line between the opposite polarities. Cancellation was the only observed means of major loss of flux in the photospheric magnetic fields of the active region. Approaching fragments of opposite polarity flux always collided and after apparent collision, permanent loss of magnetic flux was subsequently and invariably observed. Thus, cancellation is a highly predictable phenomenon.

All of the 22 flares observed during the decay of this region were initiated around the sites where magnetic flux was cancelling or was deduced to be cancelling during the flares. The intervals of time during which magnetic flux was decreasing at the flare sites was very much longer than the duration of the flares. Abrupt changes in magnetic flux on the time scales of the Ha flares were not observed. Several flares started at a site of disappearing flux but spread to other locations of plage where no loss of flux was observed during the flare. We hypothesize that cancellation was a necessary condition, but not the only necessary condition, for flares to occur in this active region.

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C.7

SMALL-SCALE ERUPTING FILAMENTS ON THE QUIET SUN

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ABSTRACT

We conducted a study of a little known class of eruptive events on the quiet sun. 61 small-scale eruptive filamentary structures were identified in a systematic survey of 32 days of H-alpha time-lapse films of the quiet sun acquired at Big Bear Solar Observatory. When fully developed, these structures have an average length of 15 arc seconds before eruption. They appear to be the small-scale analog of large-scale eruptive filaments observed against the disk. At the observed rate of 1.9 small-scale eruptive features per field of view per average 7.0 hour day, we estimate the rate of occurrence of these events on the sun to be greater than 600 per 24 hour day. The average duration of the eruptive phase was 26 minutes while the average lifetime from formation through eruption was 70 minutes. A majority of the small-scale filamentary structures were spatially related to cancelling magnetic features in line-of-sight photospheric magnetograms. Similar to large-scale filaments, the small-scale filamentary structures sometimes divided opposite polarity cancelling fragments but often had one or both ends terminating at a cancellation site. Their high numbers appear to reflect the much greater number and mixture of small-scale than large-scale aggregates of opposite polarity magnetic flux on the quiet sun. From their characteristics, evolution and relationship to photospheric magnetic flux, we conclude that the structures described in this study are small-scale eruptive filaments and are a subset of all filaments.

C.8

RECENT OBSERVATIONS OF THE FORMATION OF FILAMENTS

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ABSTRACT

Two examples of the formation of small filaments in H-alpha are described and illustrated. In both cases, the formation is seen to be the spontaneous appearance of strands of absorbing mass that evolve from no previous structure. The initial development of the filaments appears to consist of the accumulation of these absorptive strands along approximately parallel paths in a channel between large-scale, opposite polarity magnetic fields on either side of the filaments. The strands exhibit continuous changes in shape and degree of absorption which can be due to successive condensations resulting in new strands, mass motions within the strands, and outflow of the mass from the strands. For at least several hours before the formation of both filaments, small-scale fragments of opposite polarity, line-of-sight magnetic flux adjacent to or immediately below the filaments, and at the ends of the filaments, were cancelling. This type of magnetic flux disappearance continued during the development of the filaments and is commonly observed in association with established filaments. Cancellation is interpreted as an important evolutionary change in the magnetic field that can lead to configurations suitable for the formation of filaments.

D. Publications: FY1982 - FY1986

D.1 Research Papers

1. "Emerging Magnetic Flux, Flares, and Filaments" S.F. Martin, L. Dezso, A. Antalova, A. Kucera, and K.L. Harvey: 1982, Advances in Space Research, Proceedings of COSPAR XIII, May 1982, Ottawa, Canada.

2. "Dynamic Signatures of Quiet Sun Magnetic Fields" S.F. Martin: in "Small-scale Dynamical Processes in Stellar Atmospheres", ed. S.L. Keil, Sacramento Peak Observatory.

3. "Relationships of a Growing Flux Region to Flares" S.F. Martin, R. Bentley, A. Schadee, L. Dezso, L. Gezstelyi, A. Antalova, A kucera, K.L. Harvey, H.P. Jones, S.H.B. Livi, and J. Wang: 1984, Advances in Space Research, Proceedings of COSPAR XV, Graz, Austria

4. "The Disappearance of Magnetic Flux from the Quiet Sun" J. Wang, Z. Shi, S.H.B. Livi, and S.F. Martin, submitted to Solar Physics

5. "The Cancellation of Magnetic Flux I - On the Quiet Sun" S.H.B. Livi, J. Wang and S.F. Martin: Australian Journal of Physics, Proceedings of the Ron Giovanelli Commemorative Colloquium, 1985).

6. "The Cancellation of Magnetic Flux II - In a Decaying Active Region", S.F. Martin, S.H.B. Livi and J. Wang, Australian Journal of Physics (Proceedings of the Ron Giovanelli Commemorative Colloquium, 1985).

7. "Small-scale Erupting Filaments on the Quiet Sun" L.M. Hermans and S.F. Martin: "Coronal and Prominence Plasmas" ed. A. Poland, NASA Conference Publication

8. "Recent Observations of the Formation of Filaments" S.F. Martin: "Coronal and Prominence Plasmas", ed. A. Poland, NASA Conference Publication

D.2 Research Papers in Progress

1. The Formation and Decay of Sunspots Associated with Network Magnetic Fields, S.H.B. Livi and S.F. Martin

2. The Earliest Detectable Phases of New Active Regions S.F. Martin and M. Liggett

3. "The Identification and Behavior of Small-scale Magnetic Fields on the Quiet Sun" S.F. Martin

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F. Interactions

F.1 <u>Papers Presented at Formal Scientific Meetings</u>

1. "A Formula for Forecasting the Eruption of Quiescent Filaments" S.F. Martin and G. Lawrence, AAS Meeting, Boulder, Colorado, 10-13 Jan. 1982.

2. "Growth Rates of Active Regions", L.M. Hermans and S.F. Martin, Solar Physics Division of the AAS, Pasadena, 22-24 June 1983.

3. "Dynamic Signatures of Quiet Sun Magnetic Fields" S.F. Martin, Conference on Small-scale Dynamical Processes in Stellar Atmospheres, Sacramento Peak Observatory, 25-29 July 1983.

4. "The Earliest Signs of New Active Regions" poster paper presented at AAS Meeting, Las Vegas, Jan. 1984.

5. "Predicting the Eruption of Filaments near New Active Regions", S.F. Martin, Solar Terrestrial predictions Workshop, 18-22 June 1984.

6. "Relationships of a Growing Magnetic Flux Region to Flares" presented by S.F. Martin in behalf of the co-authors at COSPAR XXV, Graz, Austria, July 1984.

7. "The Cancellation of Magnetic Flux I - On the Quiet Sun" S.H.B Livi, J. Wang and S.F. Martin, presented by S.H.B. Livi at the Ron Giovanelli Commemorative Colloquium II, Tucson, 17-18 January 1985

8. "The Cancellation of Magnetic Flux II - In a Decaying Active Region", presented by S.F. Martin at the Ron Giovanelli Commemorative Colloquium II, Tucson, 17-18 January 1985

9. "The Disappearance of Magnetic Flux and the Mysterious Formation of Filaments", presentation by S.F. Martin at the Coronal and Prominenece Plasmas Workshop, Airlie Virginia, 9-11 April 1985

10. "Microflares and their Relationship to Magnetic Flux" S.F. Martin, presented at the 1985 Sacramento Peak Summer Meeting on "The Lower Atmosphere in Solar Flares - Relationships Between Low Temperature Plasmas and High Temperature Emissions" 20-24 August 1985

11. "The Role of Disappearing Magnetic Flux in the Flare Build-up", S.F. Martin, Invited Presentation at the Flare Build-up Study Workshop, Sacramento Peak Observatory, 26-28 August 1985

12. "Small-Scale Erupting filaments on the Quiet Sun" L.M. Hermans and S.F. Martin, presented at the Coronal and Prominence Plasmas Workshop, West Virginia, April 1986.

F.2 Other Scientific Presentations

1. "Forecasting the Eruption of Quiescent Filaments in the vicinity of New Active Regions", S.F. Martin, Invited Talk to the personnel of the Solar Forecasting Center, Environmental Services, NOAA, Boulder Colorado, Jan. 1982.

2. "How Quiet is the Quiet Sun?", S.F. Martin, presented at the California Solar Neighborhood Meeting, University of California, Irvine, 23 Sep. 1983.

3. "The Disappearance of Magnetic Flux on the Quiet Sun", J. Wang, Z Shi, S.H.B. Livi and S.F. Martin, Solar Neighborhood Meeting, Owens Valley Radio Observatory, April 1984.

4. "The Cancellation of Magnetic Flux on the Quiet Sun", presented by S.F. Martin at Arcetri Observatory, Italy, July 1984.

5. "The Cancellation of Magnetic Flux on the Quiet Sun", presented by S.F. Martin at Utrecht Observatory, The Netherlands, July 1984.

6. "Quiet Sun Magnetic Fields", presented by S.F. Martin at Goddard Space Flight Center, July 1984.

7. "A Series of Flares Related to Cancelling Magnetic Flux", S.H.B. Livi, S.F. Martin and J. Wang, presentation by S.H.B. Livi and S.F. Martin at the Solar Neighborhood Meeting, California State University, Northridge, 2 November 1985.

8. "Observations Relating to the Forecasting of Solar Flares", S.F. Martin, presentation at the Stanford Workshop on Solar Flare Prediction, 28 February-1 March 1985.

9. "The Disappearance of Magnetic Flux and Flares", S.F. Martin, Invited presentation given at the Environmental Research Laboratory, NOAA, Boulder, Colorado, 16 April 1985.

10. "The Disappearance of Magnetic Flux on the Sun", S.F. Martin, Invited talk given at University of California, San Diego, 22 May 1985.

11. "The Identification and Behavior of Small-scale Magnetic Fields on the Quiet Sun", S.F. Martin, presentation at the Solar Cycle Workshop, Big Bear Solar Observatory, Aug. 1986.

12. "The Evolution of Magnetic Fields on the Quiet Sun", invited presentation by S.F. Martin at the Workshop on High Resolution in Solar Physics, Boulder, Colorado, Sep. 1986.

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